FEASIBILITY OF USING NON PROPAGATION WALLS IN AN EXISTING OPERATING FACILITY

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ABSTRACT

An existing facility has an operating requirement to maintain and refurbish torpedoes. The required explosive weight located inside the facility at any given time is 30,000 lbs. Intraline distance to adjacent ordnance operating facilities limits the maximum credible event in the facility to 15,000 lbs.

This paper presents the acceptor loads and non propagation wall design requirements to reduce the event to 15,000 lbs. For the calculated load environment, the expected reactions of the torpedo warheads will be: (1) breakup of the warhead with no reaction, or (2) breakup of the warhead with prompt burning.

The torpedo operating facility may be subdivided into two potential explosive sites using a combination of non propagation walls and an inert buffer area. Although the net explosive weight will remain at 30,000 lbs., the maximum credible event will be reduced to 15,000 lbs. and the intraline distance requirements will be satisfied

1.0 INTRODUCTION AND BACKGROUND

An explosives operating facility has an operating requirement to maintain and refurbish torpedoes. The required explosive weight located inside the facility at any given time is 30,000 lbs. However, the Intraline distance to adjacent ordnance operating facilities limits the maximum explosive weight in the torpedo facility to 15,000 lbs.

The Naval Facilities Engineering Center (NFESC) and the Naval Surface Warfare Center (NSWC), Indian Head Division, have developed a basis for the design and

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construction of Non Propagation Walls (NPWs) to divide the operating facility into two Potential Explosives Sites. The NPWs must mitigate the following two hazards: an initial mass detonation in a single potential explosive site (PES) propagating to the second PES, and an initial detonation from a single torpedo during transport propagating to both sites.

Preventing propagation of detonation between the two sites requires mitigating the following hazards: direct shock, primary fragment impact, debris impact from existing building components, and debris impact from non propagation walls. Non propagation walls will mitigate direct shock caused by blast pressures from an accidental explosion. Placing non propagation walls to eliminate line of sight between the two potential explosive sites will stop primary fragments and debris from existing building materials. Debris from the non propagation walls must satisfy reaction threshold criteria.

Operations require transport of torpedoes between the two sites, on either side of the non propagation wall, within the facility. The exposure time to each PES during transport is statistically insignificant (approximately 50 minutes per a 24 hour day). Therefore, the transport SD scenario is not considered in the design of the non propagation walls.

1.2 SCOPE

This paper summarizes and defines the following:
(1) reaction threshold criteria for acceptor ordnance,
(2) non propagation wall response to explosive loads, and acceptor response to non propagation wall debris impact,
(3) non propagation wall design criteria, and
(4) response of existing building materials to explosive loads, and acceptor response to building debris impact.

2.0 REACTION THRESHOLD CRITERIA

Two reaction threshold criteria are used to prevent SD of the acceptor ordnance by mitigating the following two hazards: (a) crushing and rupturing of the acceptor during debris impact, and (b) high pressures in the explosive fill during impact with high velocity debris. The first criteria limits the unit kinetic energy and momentum of debris which may crush and rupture an acceptor. The second criteria is a velocity limit on debris which limits the peak pressure in the explosive fill during debris impact.

The threshold reaction criteria limiting crushing is based on flyer plate and full-scale magazine testing for the High Performance Magazine (HPM) program. As part of the HPM program, all Navy ordnance has been classified into eight Storage Compatibility Groups (SCGs). These SCGs are used to identify ordnance having similar sensitivities to sympathetic detonation (SD). For each SCG, a worst case acceptor is chosen and tested to determine the maximum load environment causing SD. By definition, the worst case acceptor for a compatibility group is the acceptor most likely to sympathetically detonate.

Preventing SD of the worst case acceptor demonstrates prevention of SD for all weapons in a compatibility group.

All Navy ordnance contained in HPM SCG 8, including torpedo warheads, may be described as thin cased. Impact with large, low velocity debris results in the deformation rupturing of the thin metal casings. The rupturing of the casing may result in a low order reaction, such as burning.

The empirical data for determining sympathetic reactions are based on flyer plate crush tests designed to simulate a low velocity, massive wall impacting and crushing a warhead against a solid wall. Flyer plate tests were conducted to develop SD threshold criteria for worst case torpedo warheads (with both melt cast and plastic bonded explosives fills). Reaction threshold criteria for the warheads require that the total energy load on the warhead be less than 50% of the energy at the explosion/detonation threshold (if the threshold has been established by test), or 75% of the energy at the highest tested burn reaction (2.4 ft-k/in^3) while not exceeding the maximum tested unit impulse (69 psi-sec). Detailed descriptions of test setups and ordnance response to impact loads are found in Reference 1.

Full scale HPM certification tests have shown that the reaction threshold criteria, developed with flyer plate tests, ensures that SD is prevented. The acceptor warheads in the operating facility have been tested in the HPM Certification Tests and no SD occurred using the HPM reaction threshold criteria.

The debris velocity criteria is based on non propagation wall velocities calculated for certification tests of the High Performance Magazine. The calculated design velocities of the NPWs in the HPM Certification Tests Nos. 1 and 2 ranged from 305 to 360 feet per second. These tests have demonstrated that SD of acceptor warheads is prevented at these wall velocities. Because these tests provide the best available data on successful prevention of SD, the velocity limit will not exceed walls velocities calculated for the High Performance Magazine. The design velocity for the NPWs in the operating facility will be limited to 360 feet per second.

3.0 NPW RESPONSE AND ACCEPTOR RESPONSE TO DEBRIS IMPACT

This section defines the following: (a) location of the potential explosive sites, buffer area, and potential non propagation walls, (b) the load environment and the NPW response, and (c) the response of acceptors to impact with NPW debris

3.1 PES Locations

As shown in Figure 1, Potential Explosive Site No. 1, PES-1, includes Rooms 100, 108 and Rooms 107-A through 107-D. Potential Explosive Site No. 2, PES-2, includes Rooms A100, A101, A107, A108 and the Spray Booth.

The Buffer Area includes Room 104 and a section of Room 100. Room 100 is used for inert storage and provides space for transporting torpedoes between the two potential explosive sites.

3.2 Load Environment and NPW Response

Loading environments calculated for the two potential explosive sites are based on the following two worst case hazard scenarios:

(a) an accident in PES-1 assumes detonating a 15,000 lb. donor located at the center of Room 100, and
(b) an accident in PES-2 assumes detonating a 15,000 lb. donor located near the center of Room A100.

The loading environment for each hazard scenario includes the combined shock and gas impulse loads calculated by the computer codes, SHOCK and FRANG. SHOCK calculates the shock pressure and impulse on a flat surface bounded by one to four rigid reflecting surfaces. The shock impulse includes the effects from incident shock waves and any reflected waves from the reflecting surfaces. FRANG calculates the impulse from internal gas pressures resulting from a confined explosion. The software calculates the change in internal pressure as gas vents through openings, and accounts for frangible panels.

For the 15,000 lb. donor detonating at the center of Room 100, the loading is calculated on Line C for a potential NPW extending from Room 107-A to Room 103 and separating the Buffer Area from Room 100 (See Figure 1). The roof, floor, and walls surrounding Room 100 are assumed to be reflecting surfaces for shock loads. The gas impulse loading is calculated assuming the roof to be a frangible panel.

For the 15,000 lb. donor detonating near the center of Room A100, the loading is calculated for a potential NPW on Line D extending the length of Room A100, and separating the Buffer Area from Room A100 (See Figure 1). The roof, floor, and walls surrounding Room A100 are assumed to be reflecting surfaces for shock loads. The gas impulse loading is calculated assuming the roof to be a frangible panel.

Table 1 lists the predicted loads and response of the two potential NPWs located on Lines C and D. Wall response, such as kinetic energy, momentum, and velocity, are dependent on the load environment and the weight of the wall. The potential thickness

and areal weight of each wall are listed in columns one and two. As shown in columns three through five, decreasing the wall weight increases the wall velocity and the unit kinetic energy. Increasing the wall weight will decrease the wall velocity and the unit kinetic energy.

3.3 Predicted Acceptor Response to NPW Debris Impact

This section compares the two SD criteria with the calculated load environment on acceptor ordnance. These two criteria prevent SD of the acceptor ordnance by mitigating the following two hazards: (a) crushing and rupturing of the acceptor during debris impact, and (b) high pressures in the explosive fill during impact with high velocity debris. The first criteria limits the unit kinetic energy and momentum of debris which may crush and rupture an acceptor. The second criteria are a velocity limit on debris to mitigate peak pressure in the explosive fill during debris impact.

3.3.1 Crushing Criteria

By definition, the worst case acceptor is the ordnance most sensitive to SD for the thin case acceptors in compatibility Group 8. Unit energy is defined as the kinetic energy of the non propagation wall within an effective wall area divided by the volume of the acceptor. Unit impulse is defined as the momentum of the non propagation wall within an effective wall area divided by the projected area of the acceptor. The effective wall area loading a thin case munition is the projected area of the acceptor.

The crushing threshold criteria limits the unit impulse and energy design loads on thin case munitions to less than the 69 psi-sec and 2.4 ft-k/in^3. These criteria were developed from flyer plate test results reported in Reference 1. The expected loading on the acceptor warhead is below the criteria limits and shows SD can be prevented.

Non propagation of the acceptor and worst case torpedo warheads has been successfully demonstrated in HPM Certification Tests No.1 and No. 3 with greater calculated loads than will occur in this facility. The types of reaction of the warheads in these tests were limited to: (1) no reaction, or (2) burning of the explosive material.

3.3.2 Debris Velocity Criteria

The design velocity criteria for the debris in the operating facility limits debris velocity to 360 feet per second.   The calculated velocities for debris from the NPW, shown in Table 1, are significantly less than the SD reaction threshold criteria limits.

4.0 NON PROPAGATION WALL DESIGN CRITERIA

This section presents recommended design requirements for the non propagation walls located in the buffer area. Results of small scale (Ref. 2 and 3) and full scale tests

have demonstrated that an effective, NPW can be designed with sufficient mass to limit the velocity, momentum, and kinetic energy in order to mitigate pressure and deformation response. Crushable wall materials may also be used to limit initial impact pressures.

The wall locations, masses, lengths, and heights were chosen to keep all debris striking the acceptors below the threshold reaction criteria presented in Section 2.0.

4.1 Wall Locations. The proposed NPWs for subdividing the operating facility include three sections: (1) a NPW on Line C separating the Buffer Area from PES-1, (2) an exterior NPW at the spray booth, and (3) a lightweight concrete barricade located in the buffer area. The first wall consists of the existing reinforced concrete wall separating Rooms 107-A and 104 and a new lightweight concrete wall extending from Room 107-A through Room 103, as shown in Figure 2. The lightweight concrete barricade wall is located in the Buffer Area and sized to stop line of sight fragments from passing between PES-1 and PES-2 (See Figure 2). The location of the barricade wall permits transport of torpedoes through the Buffer Area while preventing line of sight fragments between PES-1 and PES-2.

4.2 Wall Mass. For both non propagation walls and the barricade wall, the wall mass must be sufficient to: (1) ensure the wall's unit impulse and unit kinetic energy are lower than reaction threshold criteria, and (2) the wall's velocity is lower than wall velocities calculated for the HPM certification tests. The material properties of the concrete are listed in Table 2. These properties are required to ensure breakup of the wall into small debris with low momentum and kinetic energy.

The properties of the lightweight concrete require the 28 day f'_c to be greater than 1500 psi and less than 3000 psi and the wet density to be less than 95 pcf. The minimum required areal density for the wall cross-section is 206 psf. (This areal density is the sum of 2'-0" of lightweight concrete times a density of 95 pounds per cubic foot.)

The steel reinforcement area shall be kept to a minimum for meeting ACI building code requirements. The size of individual rebar and stirrups should be kept $\leq$ 3/8 inch diameter.

4.3 Wall Geometry. All existing walls are constructed from concrete masonry blocks with grouted reinforcement, except for the reinforced concrete walls surrounding Rooms 107-A through 107-D. Debris from the existing concrete masonry walls must satisfy reaction threshold criteria or be throw in a direction away from any acceptors. Based on the calculated load environment, debris velocities for existing concrete masonry blocks may exceed 1800 ft/s. These velocities far exceed safe limits. Dispersal of the building debris during an accidental explosion may exceed 20 degrees off the axis normal to a wall and may impact acceptor ordnance in the adjacent potential explosive site.

The minimum required height for the NPW in separating the Buffer Area and PES-1 will be 23' to mitigate the debris hazard from the existing concrete block wall on Line D

(see Section 5.1.2).   The required height for the exterior NPW wall located by the Spray Booth will be the full height of the Spray Booth.

The required wall height for the barricade wall located in the Buffer Area is ten feet to stop line of sight primary fragments from traveling between PES-1 and PES-2.

5.0 HAZARDS ASSOCIATED WITH EXISTING BUILDING COMPONENTS

In addition to debris from NPWs, debris originating from existing building components must not cause SD of acceptor ordnance.   Building components which are reviewed and analyzed include: existing concrete masonry block walls, light wall panels, the built up roofs located above PES-1 and PES-2, and the existing reinforced concrete walls surrounding Rooms 107-A through 107-D.

5.1 Load Environment and Response of Individual Building Components. Loading environments calculated for the building components are based on the following two hazard scenarios:

(a) an accident in PES-1 assumes detonating a 15,000 lb. donor located at the center of Room 100 (See Figure 3), and
(b) an accident in PES-2 assumes detonating a 15,000 lb. donor located near the center of Room A100 (See Figure 3).

The donor for each hazard scenario is assumed to be a hemispherical explosive. Pressure and impulse are determined from shock wave parameters for a hemispherical TNT explosion as found in Reference 4. The incident blast loads are applied to building components to determine their velocity, momentum, and kinetic energy.

In case of an accident in PES-1, the existing reinforced concrete walls separating Rooms 107-A though 107-D from Room 100 represents a loaded surface exposed to a confined explosion (See Figure 3). The load environment on this reinforced concrete wall is calculated using SHOCK and FRANG, see Section 5.0. The roof, floor, and walls surrounding Room 100 are assumed to be reflecting surfaces for shock loads. The gas impulse loading is calculated assuming the roof to be a frangible panel. Table 3 lists the average peak reflected pressure and total impulse calculated for the entire wall.

In case of an accident in PES-2, the existing reinforced concrete wall separating Room 107-A from Room 104 is conservatively assumed to represent a loaded surface exposed to a confined explosion (See Figure 3).   The assumed floor area includes sections of Rooms A100, 100, and 100 (See Figure 4). The roof, floor, and walls surrounding this assumed room are reflecting surfaces for shock loads.   The gas impulse loading is calculated assuming the roof to be a frangible panel. Table 3 lists the applied peak pressure and impulse calculated for the existing reinforced concrete wall.

The location, description, and loading environment for selected building components analyzed for potential hazards are shown in Table 3. The applied loads, either incident or reflected, are dependent on the location and orientation of the individual component with respect to the blast wave.

5.1.1 Accidental Detonation Hazard to PES-2. In case of a detonation in PES-1, building components which become a debris hazard include: the concrete block wall separating the Buffer Area from PES-2, steel roof beams and the built up roof above PES-2, and the existing reinforced concrete walls surrounding Rooms 107-A through 107-D.

The concrete block wall located on Line D (See Figure 3) consists of two different vertical cross-sections along its length. At both ends of the wall, the concrete blocks extend to the full wall height (25' < h < 29'). Along the middle section of the wall, the concrete extend to a height of 18'-8" (See Figure 5). A lightweight panel constructed from 6" aluminum studs sheathed in gypsum board sets on top of the concrete blocks and extends to the full height of the wall. This lightweight panel is considered nonhazardous because the material has low impedance and breaks into small debris.

Concrete blocks located 23' or more above the floor of the facility are exposed to reflected pressures and impulses of 818 psi and 2.037 psi-sec (See Table 3). Table 4 shows the calculated velocity, momentum, and kinetic energy of concrete block debris based on these blast loads.

The roof above PES-2 consists of steel sheets and rigid insulation supported on W14x22 and W16x26 steel beams. The calculated velocity, momentum, and kinetic energy of these beams assume an incident impulse of 0.60 psi-sec applied against the top flange. As shown in Table 4, a W14x22 steel beam applies a 0.834 psi-sec unit impulse and a 0.00133 ft-k/in^3 load to the warhead. A W16x26 steel beam applies a 1.359 psi-sec unit impulse and a 0.00202 ft-k/in^3 load to the warhead. The calculated velocities of these beams range from 49 to 52.6 ft/sec.

The existing reinforced concrete wall separating Rooms 107-A though 107-D from Room 100 is constructed from normal weight. As listed in Table 3, the average impulse load on the wall is 10.78 psi-sec. As shown in Table 4, the calculated loading on an acceptor warhead is 10.78 psi-sec unit impulse and a 0.0563 ft-k/in^3 load.

5.1.2 Accidental Detonation Hazard to PES-1. In case of a detonation in PES-2, building components, which become debris include: the concrete block wall separating the Buffer Area from PES-2, steel roof beams and the built up material in the roof above PES-1.

The roof above PES-2 consists of steel sheets and rigid insulation supported on W10x11.5, W10x21 and W18x35 steel beams. The W18x35 steel beams span the width of Room 100 and support steel trusses spanning the length of the room.

The calculated velocity, momentum, and kinetic energy of these beams assume an incident impulse of 0.637 psi-sec applied against the top flange. As shown in Table 4, a W10x11.5 steel beam applies a 0.834 psi-sec unit impulse and a 0.00133 ft-k/in^3 load to the warhead. A W16x26 steel beam applies a 1.359 psi-sec unit impulse and a 0.00202 ft-k/in^3 load to the warhead. The calculated velocities of these beams range from 42 to 90 ft/sec.

The sections of the full height concrete block wall located on Line D of Figure 1 will create debris during an accidental detonation in PES-2. The location of concrete blocks and lightweight panels in this wall are described in Section 5.1.1. The 23' NPW on Line C eliminates line of sight paths from this debris to acceptors located in Rooms 107-A through 107-D, and Room 100.

The existing reinforced concrete wall separating Rooms 107-A from Room A100 is constructed from normal weight concrete. As listed in Table 3, the average impulse load on the wall is 5.303 psi-sec. As shown in Table 4, the calculated loading on an acceptor warhead is 5.303 psi-sec unit impulse and a 0.0136 ft-k/in^3 load.

5.2 Acceptor Reaction to Impact with Individual Building Components. As stated in Section 2.0, the crushing reaction threshold criteria for the acceptor warheads requires that the unit kinetic energy load to be less than 2.4 ft-k/cu. in., and the unit impulse to be less than 69 psi-sec. None of the building components, shown in Table 4, had unit impulses or unit kinetic energy loads, which exceed the crushing reaction threshold criteria.

The design velocity for the debris in the operating facility will be limited to 360 feet per second. The loads from components, shown in Table 4, are significantly less than the SD reaction threshold criteria limits.

6.0 RECOMMENDATIONS

The operating facility may be subdivided into two potential explosive sites using a combination of non propagation walls and an inert buffer area. The intraline distance for the operating facility will limit the maximum explosive capacity of each potential explosive site to 15,000 lbs. NEW. The maximum explosive capacity of the operating facility, 30,000 lbs. NEW, is the sum of the explosive limits for the two sites.

This document presents criteria required for preventing prompt SD of the torpedoes. For the calculated load environment, the expected reactions of torpedo warheads will be: (1) breakup of the warhead with no reaction, or (2) breakup of the warhead with prompt burning.

To prevent prompt propagation of detonation between the two sites, the following criteria must be followed:

1. A buffer area, separating the two explosive sites, will be created using Rooms 100 and 104. This buffer area will be used for inert storage.

2. A non propagation wall will be located on Line C (See Figure 2). This non propagation wall includes two sections: (a) the existing reinforced concrete wall adjacent to Room 107-A, and (b) a new wall lightweight concrete wall, 23' tall and 24" thick, at Rooms 100 and 103.

3. A non propagation barricade wall constructed from lightweight concrete will be located in the buffer area to stop line-of sight fragments and debris which enter the buffer area through the doors. The barricade wall will be 24" thick by 10' tall.

4. A non propagation wall added to the exterior wall of the Spray Booth located in PES-2 (See Figure 2). The wall must be 24" thick and constructed from the specified light weight concrete. The required height for this non propagation wall will be the exterior height of the Spray Booth.

5. The required material properties for the light weight concrete include a density less than 95 pcf and a 28 day f'_c greater than 1500 psi and less than 3000 psi. The steel reinforcement shall be kept to a minimum for meeting ACI building code requirements. The size of individual rebar and stirrups shall be kept $\leq$ 3/8 inch diameter unless approved by NFESC.

7.0 REFERENCES

1. "High Performance Magazine Acceptor Threshold Criteria", James E. Tancreto (NFESC), Michael Swisdak (NSWC) and Javier Malvar (UC Davis), Twenty-Sixth DOD Explosives Safety Seminar, Miami, FL, August 1994

2. "AUTODYN-2D Predictions for Small Scale HP Magazine Cell Wall Tests", Kevin Hager and James Tancreto, Twenty-Fifth DOD Explosives Safety Seminar, Anaheim, CA, August 1992

3. "Development of HPM Non propagation Walls: Test Results & Autodyn-2D Predictions of Wall Effectiveness", Kevin Hager and James Tancreto, Twenty-Sixth DOD Explosives Safety Seminar, Miami, FL, August 1994

4. Structures to Resist the Effects of Accidental Explosions, Chapter Two, NAVFAC P-397.

Table 1. Predicted Loads and Response for Potential Non Propagation Walls

Donor and Wall Locations	Wall Thickness (ft)	Wall Weight[1] (psf)	Wall Velocity[2] (ft/s)	Unit Impulse [3] (psi-sec)	Unit Kinetic Energy (ft-k/in^3)
Room 100 Line C	3.0	285	229	14.09	0.098
Room 100 Line C	2.5	238	275	14.09	0.117
Room 100 Line C	2.0	190	345	14.09	0.147
Room A100 Line D	3.0	285	255	15.59	0.120
Room A100 Line D	2.5	238	304	15.59	0.144
Room A100 Line D	2.0	190	381	15.59	0.180

[1] Wall weight is based on the wall thickness and wall density (wall weight = wall thickness in feet times a density of 95 pounds per cubic foot for the lightweight concrete).
[2] Wall velocity is calculated from the wall weight and the total unit impulse
[3] Shock impulse is the average impulse on the entire area of the wall

Table 2. Non propagation Wall Mass and Concrete Properties.

Material	Twenty Eight Day Compressive Strength (psi)	Density (pcf)	Wall Thickness (in)	Wall Weight[1] (psf)
LightWeight Concrete	$1500 \le f'_c \le 3000$	≤ 95	24	190

[1] Wall weight is based on the wall thickness and wall density (wall weight = wall thickness in feet times a density of 95 pounds per cubic foot).

Table 3. Applied loads on existing building components.

Hazard Scenario	Building Components and Locations	Peak Pressure (psi)	Applied Impulse (psi-sec)
Detonation in PES-1	CMU blocks Concrete Wall Line D	818	2.037
Detonation in PES-1	W14x22 Steel Roof Beams Room A100	148	0.600
Detonation in PES-1	W16x26 Steel Roof Beams Room A100	148	0.600
Detonation in PES-1	Existing Reinforced Concrete Wall Separating Room 100 from Rooms 107-A through 107-D	5380	10.78
Detonation in PES-2	W18x35 Steel Roof Beams, Room 100	193	0.637
Detonation in PES-2	W10x21 Steel Roof Beams Rooms 107-A through 107-D	193	0.637
Detonation in PES-2	W10x11.5 Steel Roof Beams Rooms 107-A through 107-D	193	0.637
Detonation in PES-2	Existing Reinforced Concrete Wall Line C	667	5.303

Table 4. Building component response parameters.

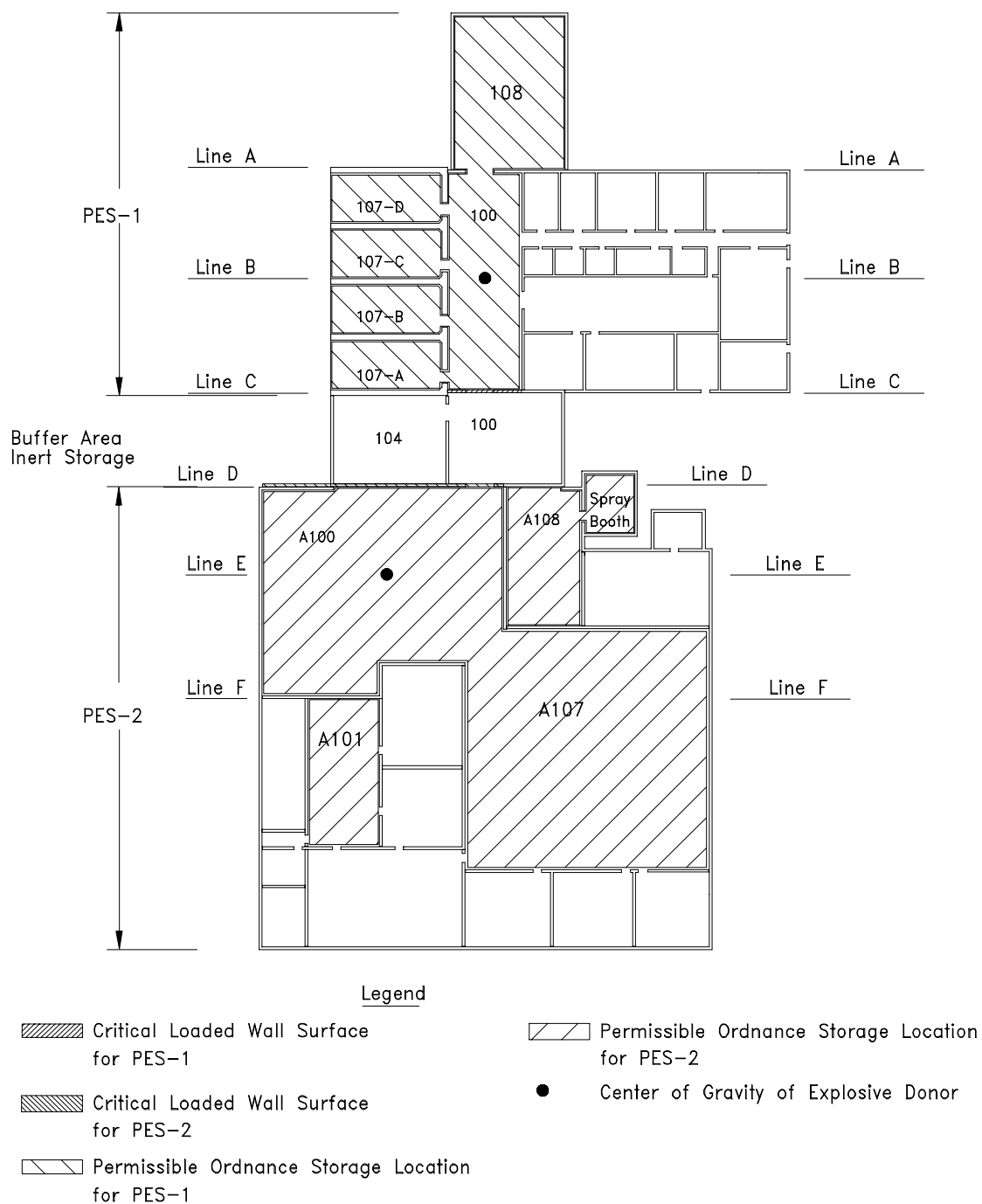| Hazard Scenario	Building Components and Locations	Velocity	Unit Impulse	Unit Kinetic Energy
		(ft/sec)	(psi-sec)	(ft-k/in^3)
Detonation in PES-1	CMU blocks Concrete Wall Line D	201	2.037	0.0124
Detonation in PES-1	W14x22 Steel Roof Beams Room A100	52.6	0.834	0.00133
Detonation in PES-1	W16x26 Steel Roof Beams Room A100	49	1.359	0.00202
Detonation in PES-1	Existing Reinforced Concrete Walls Rooms 1007-A through 107-D	172	10.78	0.0563
Detonation in PES-2	W18x35 Steel Roof Beams Room 100	42.2	1.535	0.00196
Detonation in PES-2	W10x21 Steel Roof Beams Rooms 107-A through 107-D	67.4	0.990	0.00202
Detonation in PES-2	W10x11.5 Steel Roof Beams Rooms 107-A through 107-D	90.4	0.727	0.00199
Detonation in PES-2	Existing Reinforced Concrete Walls Rooms 1007-A through 107-D	84.8	5.303	0.0136

Figure 1. Plan view of operating facility and assumed explosive locations.
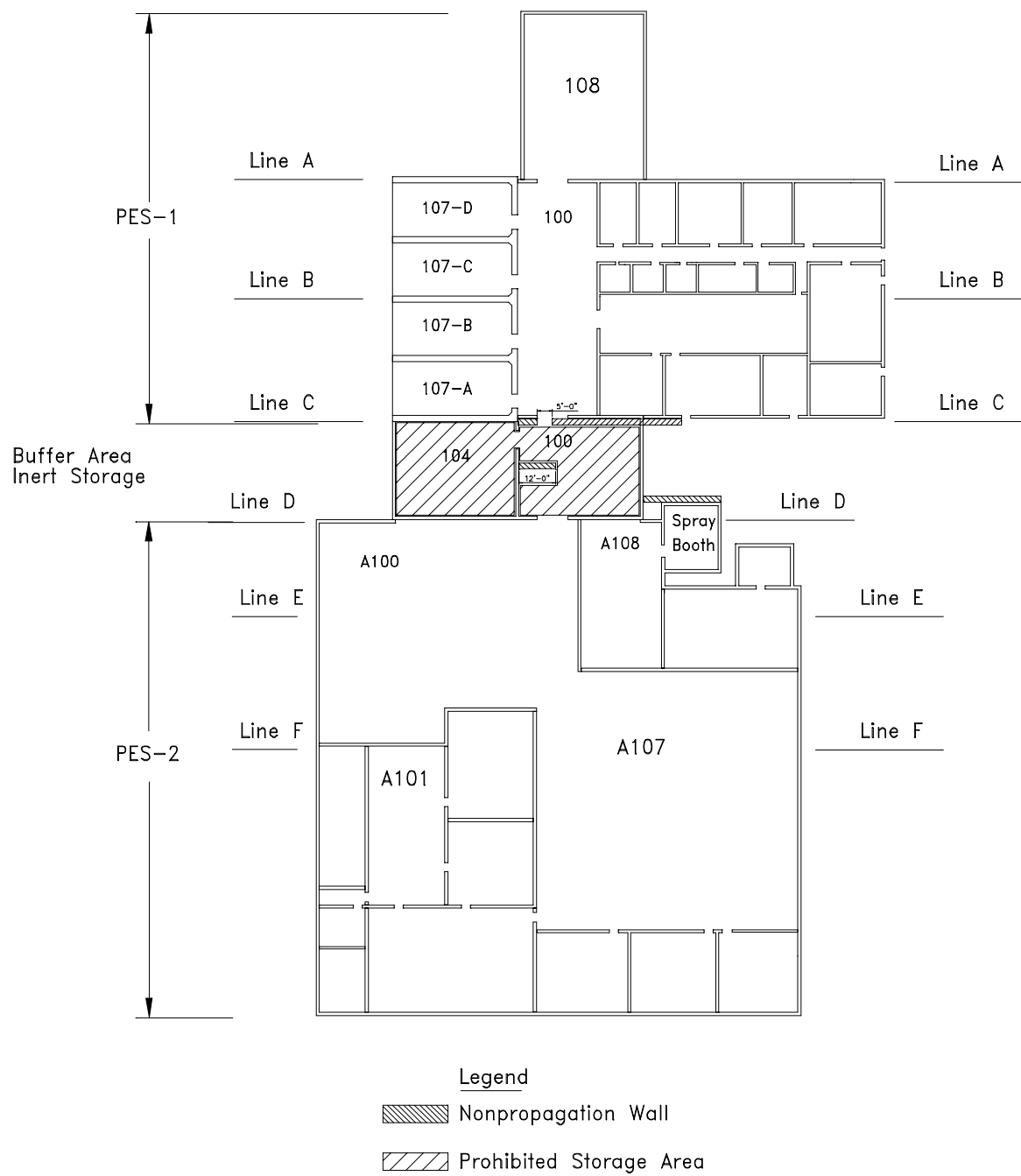
Figure 2. Location of NPWs and Prohibited Storage Areas.
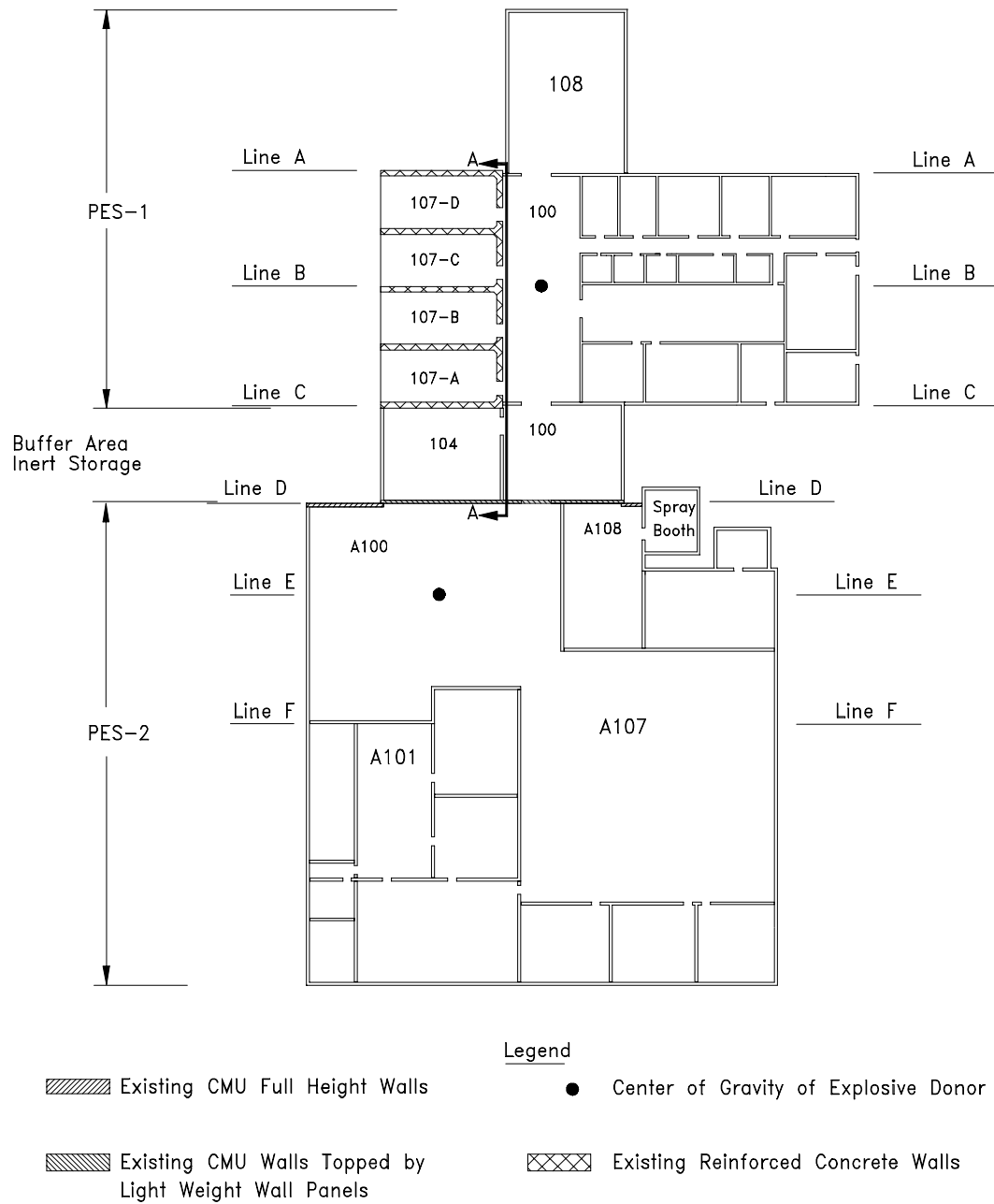
Figure 3. Explosive donor and building component locations.
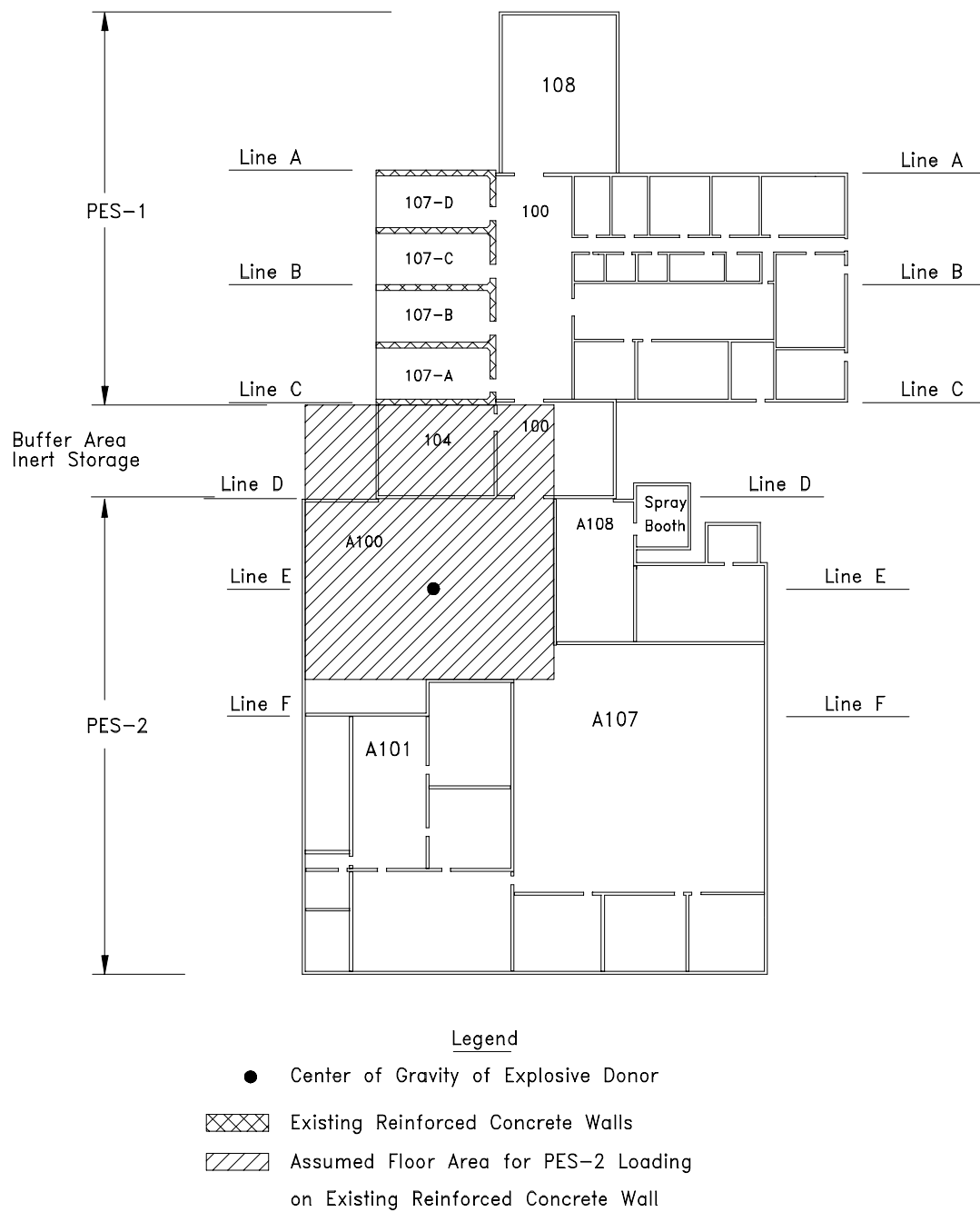
Figure 4. Plan view of assumed floor area for loading on existing concrete wall.
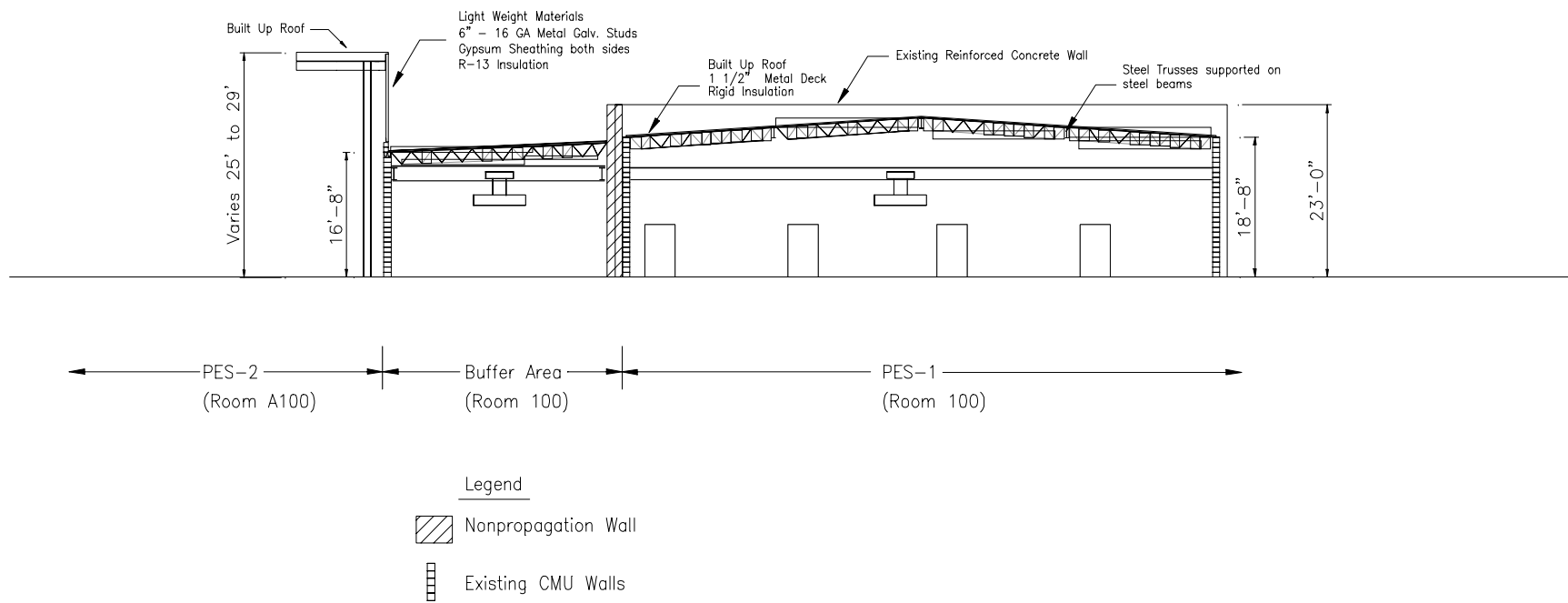
Figure 5. Potential Explosive Sites and Buffer Area of Operating Facility, Section A-A.